CLAIMS

We claim:

1. A diagnostic device for detecting the alignment of movable reflectors in an optical switch, where the optical switch includes an array of optical input fibers, an array of output optical fibers, and at least one reflector array having a plurality of movable mirrors where each mirror can occupy a plurality of positions, the movable mirrors configured to steer input light beams received from the array of input optical fibers along a signal path so that each input light beam can be switched to one of a plurality of output optical fibers as an output beam, the device comprising:

a two-dimensional photoimager positioned to receive light from the reflector array to create a two-dimensional image of the reflector array and wherein each movable mirror of the reflector array reflects light to a different two-dimensional position on the photoimager depending on the current position of each movable mirror; and

a controller that is able to adjust the movable mirrors of the reflector array according to light received at the photoimager.

2. A diagnostic device as in Claim 1, wherein the array of optical input fibers and the array of output optical fibers are included as part of a single optical fiber array.

3. A diagnostic device as in Claim 1, wherein the optical switch further includes:

a first beam splitter arranged to reflect a portion of the light from each output beam into the two-dimensional photoimager.

4. A diagnostic device as in Claim 3, wherein the optical switch further includes:

a second two-dimensional photoimager connected to the controller; and

a second beam splitter arranged to reflect a portion of the light from each input beam into the second two-dimensional photoimager, wherein the controller can adjust the

movable mirrors of the reflector array according to light received at the photoimager and the second photoimager.

5. A diagnostic device as in Claim 1, wherein each reflector array further includes a corresponding monitor illumination source positioned to illuminate the movable mirrors of the reflector array so that light from the illumination source is reflected by the movable mirrors onto the two-dimensional photoimager to create a two-dimensional image of the reflector array and wherein each movable mirror of the reflector array reflects light to a different two-dimensional position on the photoimager depending on the current position of each movable mirror.

6. A diagnostic device as in Claim 5, wherein the two-dimensional photoimager comprises an array of position sensitive photodetectors.

7. A diagnostic device as in Claim 5, wherein the two-dimensional photoimager comprises a photosensor array.

8. The diagnostic device of Claim 7, wherein the photosensor array includes a CCD detector array.

9. The diagnostic device of Claim 7, wherein the photosensor array includes an array of CMOS photodetectors.

10. The diagnostic device of Claim 7, wherein the photosensor array includes an array of quadrature photodetectors.

11. The diagnostic device of Claim 5, wherein the two-dimensional photoimager includes:

an array of bi-stable mirror elements;

a duolateral position sensitive photodetector; and

wherein the monitor illumination source projects light onto the mirrors of the reflector array which is reflected from the mirrors onto the bi-stable mirror elements which are selectively activated to selectively reflect light from the activated bi-stable mirror elements onto the duolateral position sensitive photodetector so that the duolateral position sensitive photodetector can detect the orientation of the movable reflector corresponding to the activated bi-stable mirror element.

12. A diagnostic device as in Claim 5, wherein the monitor illumination source generates an array of monitor beams that are directed onto corresponding movable mirrors of the reflector element so that each monitor beam is reflected by its corresponding movable mirror onto the two-dimensional photoimager to create a two-dimensional image of the reflector array.

13. A diagnostic device as in Claim 12, wherein the array of monitor beams is generated by a plurality of laser beams arranged to provide the array of monitor beams.

14. A diagnostic device as in Claim 12, wherein the array of monitor beams is generated by a single laser beam split into a plurality of monitor light beams to generate the array of monitor beams.

15. A diagnostic device as in Claim 5, wherein the light from the illumination source is transmitted at a first wavelength and the input light beams are transmitted in at least one other wavelength.

16. A diagnostic device as in Claim 15, wherein the light from the illumination source is transmitted at a wavelength of less than about 1 μm and wherein the input light beams are transmitted having a wavelength of greater than 1 μm.

17. A diagnostic device as in Claim 15, wherein the reflector array includes an anti-reflective covering having a first transmission bandwidth for transmitting light from the illumination source at the first wavelength and a second transmission bandwidth for transmitting the input light beams at the at least one other wavelength.

18. A diagnostic device as in Claim 17, wherein the first transmission bandwidth of the anti-reflective covering transmits light in a bandwidth between about 0.75 μm to about 0.85 μm and wherein the second transmission bandwidth transmits light at greater than about 1 μm and wherein the anti-reflective covering has satisfactory optical performance for optical beams incident on the anti-reflective covering at angles ranging from about 5 degrees to about 55 degrees.

19. A diagnostic device as in Claim 17, wherein the light from the illumination source is transmitted at a wavelength in the range of about 0.75 μm to about 0.85 μm and wherein the input light beams are transmitted having a wavelength in the range of about 1.3 μm to about 1.55 μm.

20. A diagnostic device as in Claim 1, further including a dedicated optical channel for calibrating the switch for temperature effects.

21. A diagnostic device as in Claim 20, wherein the dedicated optical channel includes

a laser that produces a calibration light beam which is directed onto a movable mirror of the reflector array;

a detector for receiving the calibration beam from the movable mirror of the reflector array; and

wherein the controller is electrically connected between the detector for receiving the calibration beam, photoimager, and the reflector array, which is able to account for temperature dependant variation in measurement of reflector position and adjust the movable mirrors of the reflector array accordingly.

22. A diagnostic device as in Claim 1, wherein one of the input light beams is used for calibrating the switch for temperature effects.

23. A diagnostic device in an optical switch having an array of optical input fibers configured to carry input light beams; an array of output fibers; at least one switching element having a reflector array with a plurality of movable mirrors, each movable mirror adjustable to a plurality of positions, suitable for reflecting selected input light beams received from selected input fibers into selected output fibers enabling the switching of each input light beam along a signal path to one of a plurality of output fibers as an output beam; the diagnostic device comprising:

an illumination source for directing at least one monitor light beam onto the movable mirrors of the reflector array;

a photoimager arranged to receive monitor light beams reflected from the movable mirrors of the reflector array to provide two-dimensional information concerning the position of the movable mirrors, with each movable mirror of the reflector array reflecting light onto a different two-dimensional position on the photoimager depending on which one of the plurality of positions each mirror currently occupies; and

a controller for adjusting the position of the movable mirrors of the reflector array according to light received at the photoimager.

24. In the optical switch of Claim 23, wherein the array of optical input fibers and the array of output optical fibers are included as part of a single optical fiber array.

25. The diagnostic device of Claim 23, wherein the illumination source is positioned with respect to the photoimager such that the monitor light beams reflected from the movable mirrors of the reflector array are not coincident with the signal path.

26. The diagnostic device of Claim 25, wherein the illumination source generates an array of monitor light beams that are directed onto the movable mirrors of the reflector array.

27. The diagnostic device of Claim 26, wherein the array of monitor light beams is generated by a single laser beam split into a plurality of monitor light beams.

28. The diagnostic device of Claim 26, wherein the photoimager includes a detector selected from the group consisting of an array of CCD photodetectors, an array of CMOS photodetectors, an array of quadrature photodetectors, a single duolateral position sensitive photodetector, and an array of duolateral position sensitive photodetectors.

29. The diagnostic device of Claim 23, wherein the monitor light beams illuminate the movable mirrors of the reflector array with light having a first wavelength and wherein the input and output beams are at another different wavelength.

30. The diagnostic device of Claim 29, wherein the input and output beams at another different wavelength comprise light beams at a plurality of different wavelengths.

31. The diagnostic device of Claim 29, wherein the reflector array includes an anti-reflective coating that has a transmission peak for transmitting monitor beams having the first wavelength and a transmission bandwidth for transmitting the input and output beams at the another different wavelength.

32. The diagnostic device of Claim 31, wherein the optical characteristics of the anti-reflective coating are optimized for light beams incident on the anti-reflective coating at angles ranging from about 5 degrees to about 55 degrees and wherein the anti-reflective coating includes a transmission peak centered at about 0.8 μm and a transmission bandwidth for transmitting light at wavelengths greater than 1.0 μm.

33. The diagnostic device of Claim 23, wherein the monitor light beams illuminate the movable mirrors of the reflector array with light having a first wavelength less than 1 μm and wherein the input and output beams are at another wavelength greater than 1 μm.

34. The switch of Claim 23, wherein the photoimager includes a duolateral position sensitive photodetector.

35. The switch of Claim 34, wherein the photoimager, including the duolateral position sensitive photodetector, further includes:

an array of bi-stable mirror elements positioned such that the light reflected from the reflector array is projected onto the bi-stable mirror elements which are selectively activated to selectively reflect the light onto the duolateral position sensitive light detector so that the duolateral position sensitive light detector can detect the orientation of a movable mirror that corresponds to the activated bi-stable mirror element.

36. An anti-reflective coating for receiving light incident at angles ranging from about 5 degrees to about 55 degrees and transmitting the light in a first bandpass region for transmitting light having a wavelength of less than 1 μm and a second bandpass region for transmitting light having a wavelength of greater than 1 μm.

37. An anti-reflective coating as in Claim 36, wherein the first bandpass region transmits light in a wavelength range of about 0.75 μm to 0.85 μm and a second bandpass region for transmitting light having a wavelength of greater than about 1.1 μm.

38. An anti-reflective coating as in Claim 36, wherein the anti-reflective coating is comprised of alternating layers of Ta_2O_5 and SiO_2 materials.

39. A method for detecting whether movable mirrors in an optical switch have a desired orientation, the optical switch having an array of optical input fibers configured to carry input light beams; an array of output fibers; at least one switching element having a

reflector array with a plurality of movable mirrors, each movable mirror adjustable to a plurality of positions, suitable for reflecting selected input light beams received from selected input fibers into selected output fibers enabling the switching of each input light beam along a signal path to one of a plurality of output fibers as an output beam, the method comprising the steps of:

directing at least one light beam onto movable mirrors of a reflector array in an optical switch;

receiving at least one light beam reflected from the movable mirrors of the reflector array such that the light beam can form an optical image of the at least one reflected beam;

detecting the two-dimensional position of the at least one reflected light beam;

comparing the two-dimensional position of the reflected light beam with a desired two-dimensional position that corresponds to that of a movable mirror having the desired orientation; and

determining whether the movable mirror is positioned having the desired orientation.

40. The method of Claim 39, further including the step of adjusting the movable mirror if the movable mirror is not positioned having the desired orientation, the adjusting continuing until the movable mirror attains the desired orientation.

41. The method of Claim 39, wherein the steps of directing and receiving include directing the light beam onto movable mirrors of a reflector and receiving the light beam once reflected from the corresponding movable mirrors in a manner such that the optical path of the monitor beams is not coincident with the signal path.

42. The method of Claim 39, wherein the steps of:

directing the light beam onto the movable mirrors of a reflector includes directing an array of monitor light beams onto corresponding movable mirrors of the reflector array; and

receiving the light beam includes receiving the monitor light beams once reflected from the corresponding movable mirrors of the reflector array.

43. The method of Claim 42, wherein the step of receiving the monitor light beams reflected from the movable mirrors of the reflector array includes selectively reflecting the received monitor light beams;

and wherein the step of detecting includes the step of detecting the two-dimensional position of the selectively reflected monitor light beams.